

EXTENDED RANGE HALL EFFECT DISPLACEMENT SENSOR

BACKGROUND OF THE INVENTION

[0001] This application relates to a displacement sensor utilizing a Hall effect sensor and a magnet, wherein the travel of the Hall effect sensor is non-parallel to an axis between the poles of the magnet, extending the range of the displacement sensor.

[0002] One known type of displacement sensor includes a Hall effect sensor placed adjacent to a magnet. The Hall effect sensor and the magnet are attached to different objects. The two objects move relative to each other, and the Hall effect sensor, by sensing the relative position of the magnet, can determine the amount of relative movement of the objects.

[0003] Such displacement sensors have had limited application in that there is typically a limited distance range which can be measured. As an example, typical production Hall effect displacement sensors are able to measure approximately .25" of movement.

[0004] For many applications, the Hall effect sensor and its .25" range would be insufficient. One example is a displacement sensor for sensing the amount of movement of a piston in a disc brake due to friction surface wear. As known, a brake actuator drives a pair of pistons in a disc brake, and the pistons force a brake pad against a rotating component, slowing rotation of the rotating component. There is normal wear on the brake pad, and typically a disc brake piston is provided with an adjustment mechanism. The adjustment mechanism has historically included a mechanical linkage that senses the total movement, and adjusts the piston relative to a tappet gear to take up clearance. Typically, there is a desired amount of piston movement, and with wear on the brake pad, the piston needs to

move an amount beyond this desired amount. Thus, the adjustment mechanism changes a rest, or starting position of the piston such that it only needs to move the desired amount, even with wear on the brake pad.

[0005] More recently, electric motors have been developed for replacing the mechanical linkage in the adjustment mechanism. An electric motor typically drives a gear, that in turn will drive the tappet gears to adjust the pistons.

[0006] Such an electric motor adjustment mechanism would benefit from feedback of the amount of necessary adjustment. Thus, some sensor for sensing the amount of movement of the pistons is desirable. The limited range provided by the current Hall effect displacement sensors is inadequate for this application. On the other hand, in the vicinity of the disc brake and its pistons, there is limited available space. For this reason, the relatively small Hall effect sensor would be quite desirable.

SUMMARY OF THE INVENTION

[0007] In a disclosed embodiment of this invention, a Hall effect sensor is positioned adjacent to a magnet such that relative movement of the two extends along a path that is non-parallel to an axis drawn between the poles of the magnet. In the past, the movement of the Hall effect sensor has generally been parallel to an axis drawn between the poles of the magnet. Since the relative movement path of the sensor and the axis between the poles of the magnet is non-parallel, the total distance or "range" of movement that can be sensed extends along a much greater distance.

[0008] In one embodiment, the path can be more than three times the typical Hall effect sensor, .75", or even 1.0". This extended range is sufficient such that a Hall effect displacement sensor can be utilized to monitor the full displacement of the disc brake pistons.

[0009] The preferred application for the inventive Hall effect sensor is to monitor the displacement in a disc brake, and provide feedback to an electric motor for adjusting the position of the piston. However, other applications of the extended range Hall effect sensor would be apparent to those of ordinary skill in the art.

[0010] In a most preferred embodiment, the magnet is attached to a part that moves when the pistons move. The Hall effect sensor is fixed to be spaced by a small gap from this magnet. As the pistons move, the magnet will move relative to the Hall effect sensor. The two are positioned relative to each other such that the path of movement is non-parallel as mentioned above. More preferably, the path is along an angle that is both non-parallel and non-perpendicular to the axis between the poles. In this way, the total sensing distance is maximized.

[0011] The magnet may include a single pair of poles, or may be an arrangement including a pair of spaced magnet members each having a pair of spaced poles. In other embodiments, the magnet may be a bar magnet having pole faces, rather than distinct smaller poles. Further, in one embodiment, the magnet and sensor are guided along each other for movement in a single direction, to maintain a known and desired gap between the magnet and the Hall effect sensor.

[0012] These and other features of the present invention will become apparent when considered in conjunction with the following drawings and specification. The following is a brief description of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0013] Figure 1 shows a known electrically-adjusted disc brake.
- [0014] Figure 2A is a cross-sectional view through the Figure 1 disc brake.
- [0015] Figure 2B shows an inventive sensor and magnet mount.
- [0016] Figure 3 schematically shows a feature of movement of a first embodiment sensor.
- [0017] Figure 4 is a chart showing the output voltage vs. travel distance for the Figure 3 embodiment.
- [0018] Figure 5A shows another embodiment of the magnet.
- [0019] Figure 5B diagrammatically shows the movement of the Figure 5A magnet relative to the sensor.
- [0020] Figure 6 shows a third embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0021] Disc brake 20 is illustrated in Figure 1 having an actuator 22, as known. A brake pad 24 is driven toward an item that is to be braked by the disc brake 20. A pair of actuator assemblies 126 and 128 drives the brake pad 24 toward the item to be braked upon control of the actuator 22 as explained below.

[0022] As is known, the position of the assemblies 126 and 128 should be adjusted toward the item to be braked, or to the left as shown in Figure 1, with wear on the brake pad 24. Thus, it is known to have gear 32 and tappet gears 34 for providing adjustment. Historically, this adjustment has been mechanical. However, more recently, this

adjustment has been provided by utilizing an electric motor. Electric motor 30 is illustrated in Figure 1. Such an arrangement is shown, for example in U.S. Patent 6,293,370. A manual adjustment mechanism 134 engages one of the tappet gears 34 associated with one of the actuator assemblies, here 128. This manual adjuster 134 is provided so that an operator of the disc brake 20 can manually adjust the actuator assemblies 126 and 128 away from the item to be braked, such that the brake pad 24 can be changed.

[0023] Figure 2A is a cross-sectional view showing the adjustment gears 34 driven by the drive gear 32, and which is schematically shown as being driven by the motor 30. As can be appreciated, the actuator assemblies 126 and 128 have pistons 26 and 28 with internally threaded inner peripheries which are driven when the tappet gears 34 are rotated by the gear 32. In this manner, the pistons 26 and 28 can be advanced toward the brake pad 24 to accommodate wear. The pistons 26 and 28 are constrained against rotation, such that when the tappet gears 34 are driven to turn, the threads advance the pistons 26 and 28 forwardly.

[0024] When the actuator 22 is actuated to cause braking, the entire actuator assemblies 126 and 128, including both pistons 26 and 28 and tappet gears 34 move downwardly as shown in Figure 2A, forcing brake pad 24 towards an item to be braked 125. At the same time, through a known mechanical arrangement, the second brake pad 124 is brought against an opposed face of item 125. With wear on the brake pads 24 and 124, the amount of movement toward this braking position will increase. The motor 30 is utilized to advance the pistons 26 and 28 downwardly in Figure 2A to take up this clearance.

[0025] Preferably, a control 31 for the motor 30 should be provided information on how much to advance the pistons 26 and 28. Figure 2B shows a sensor arrangement 68,

which includes a Hall effect sensor 70 and a magnet 72. Such a sensor arrangement 68 can be utilized to provide feedback of the amount of movement of the piston, and thus an indication to a control 31 for the motor 30 of how much adjustment is necessary. In this embodiment, magnet 72 is attached to move with an element 150 which rides along the manual adjustment mechanism 134. This element 150 will move through the full braking stroke, along with both actuator assemblies 126 and 128. Now, as the pistons 26 and 28 are driven through the actuator 22, the magnet 72 moves with the element 150. When the brake is actuated in this manner, the amount of movement of the pistons 26, 28 will be related to the amount of movement of the magnet 72.

[0026] The Hall effect sensor 70 is mounted on a fixed housing portion 27. Thus, as the magnet 72 moves, the Hall effect sensor 70 remains stationary, and the magnet 72 moves relative to the Hall effect sensor 70. As shown, a gap 69 is maintained between the magnet 72 and the Hall effect sensor 70.

[0027] Figure 3 shows the relative path of movement 50 of the Hall effect sensor 70 relative to the poles of the magnet 72. As can be appreciated, the movement path 50 is non-parallel to a line drawn between the poles of the magnet 72. Moreover, another line drawn perpendicular to the line between the poles, line Y, is also at an angle to the path 50. Thus, the length of path 50 can be designed to be at a maximum while still being within an acceptable distance of the poles. That is, the extent of path 50 is greater than the extent of the path Y, and much greater than the extent of a line drawn between the north and south poles of the magnet 72. In this manner, the distance over which the sensor arrangement 68 can sense relative movement is increased. As also shown in Figure 3, the Hall effect sensor 70 is at a center point 46 on which it lies on the path between the north and south pole.

[0028] As shown in Figure 4, the output voltage of the sensor would extend both higher and lower as the sensor moves away from this position 46. The output voltage is thus indicative of the amount of movement. As can further be appreciated, a travel distance of as much as an inch may be obtained with such a simple sensor.

[0029] As shown in Figure 5A, another embodiment has a magnet housing 168 receiving the magnet 170. The sensor 172 is received in its own housing 174. As can be appreciated, a gap 178 is maintained between the magnet 170 and the sensor 172. As also can be appreciated, there are a pair of angled sides 180, angled inwardly, such that the housing 168 is closely guided on the housing 174. In this manner, movement of the magnet 170 relative to the sensor 172 is constrained except along the direction through which the pistons move when actuating the brake. In this manner, the extent of the gap 178 is predictable, and closely maintained.

[0030] Figure 5B shows the Figure 5A embodiment, somewhat schematically, but to illustrate the movement. In this embodiment, the magnet 170 is a bar magnet having opposed pole faces 192 and 194. Again, the path of movement 190 of the sensor 172 relative to the magnet 170 is non-parallel to a line drawn between these pole faces, and non-parallel to a line perpendicular to the line drawn between the pole faces. Again, this will result in an increase in the travel and sensing distance provided by the inventive Hall effect displacement sensor.

[0031] Figure 6 shows yet another embodiment 60. In embodiment 60, there are spaced magnets 62 and 64. Again, the path 66 of the sensor 68 is non-parallel to a line drawn between either pole set 62 or 64, and is also at an angle relative to the line Y drawn perpendicular to the axis between the pole sets 62 and 64.

[0032] In sum, a unique Hall effect sensor has an extended range because its path relative to a magnet is not parallel to a line drawn between the poles of the magnet.

[0033] While preferred embodiments of this invention and a preferred application for this sensor have been disclosed, a worker of ordinary skill in the art would recognize that modifications would come within the scope of this invention. For this reason, the following claims should be studied to determine the true scope and content of this invention.